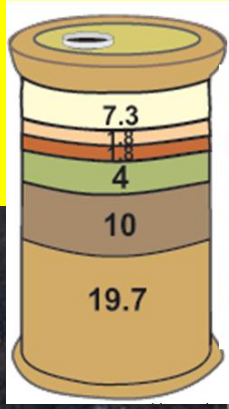

Granite
State
Clean
Cities

Biodiesel from Biodiesel

Ihab H. Farag, Sc.D.,
Chemical Engineering Dept
University of New Hampshire,
Durham, NH 03824
Phone: 1-603-862-2313
ihab.farag@unh.edu

Granite State Clean Cities Coalition Meeting, Fri March 2, 2012, DES, Pease Tradeport, Portsmouth, NH

US Consumption



- Diesel: 60 billion gal/yr
- Gasoline: 120 billion gal/yr
- 6 billion barrel per yr
- 20 million barrel per day

Source: Sprague Energy, Portsmouth, NH.

Challenges/Motivation

- Petroleum Price Volatility
- Increased Demand
- Climate Change
- EPA's new Fuels standards
- Government Acts

Source: Sprague Energy, Portsmouth, NH.

Crude Oil Prices

Less demand for fuel oil
Crude oil: heavier and more diverse
Carbon footprint
Water footprint

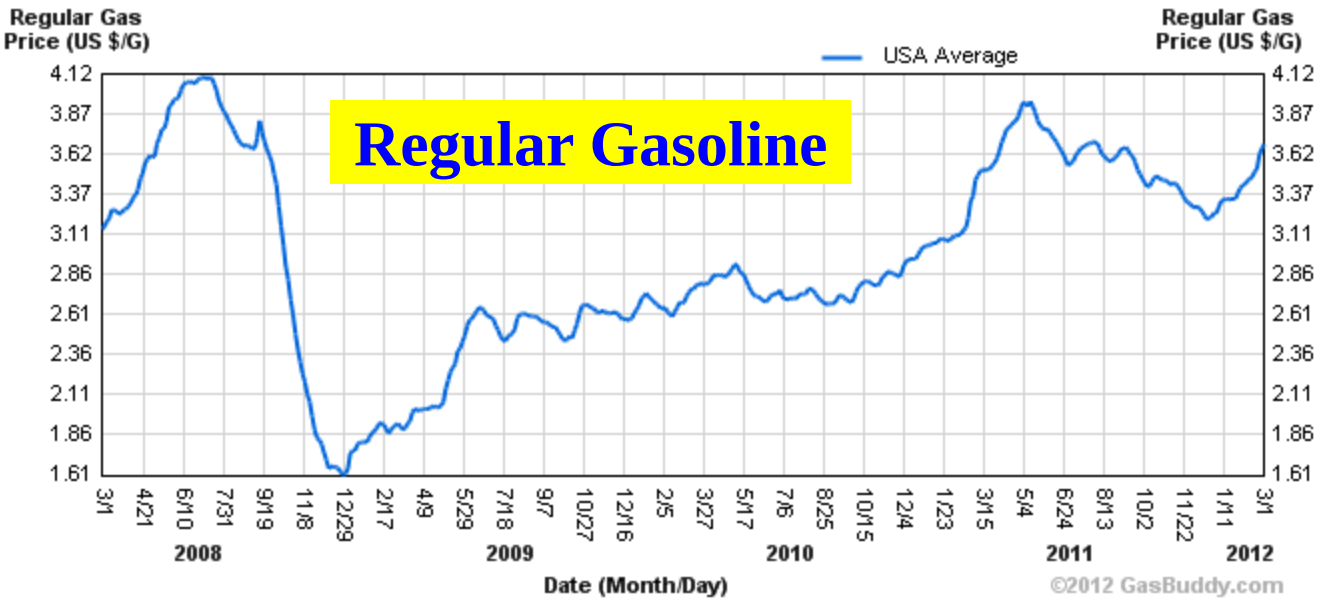
Crude Oil Prices

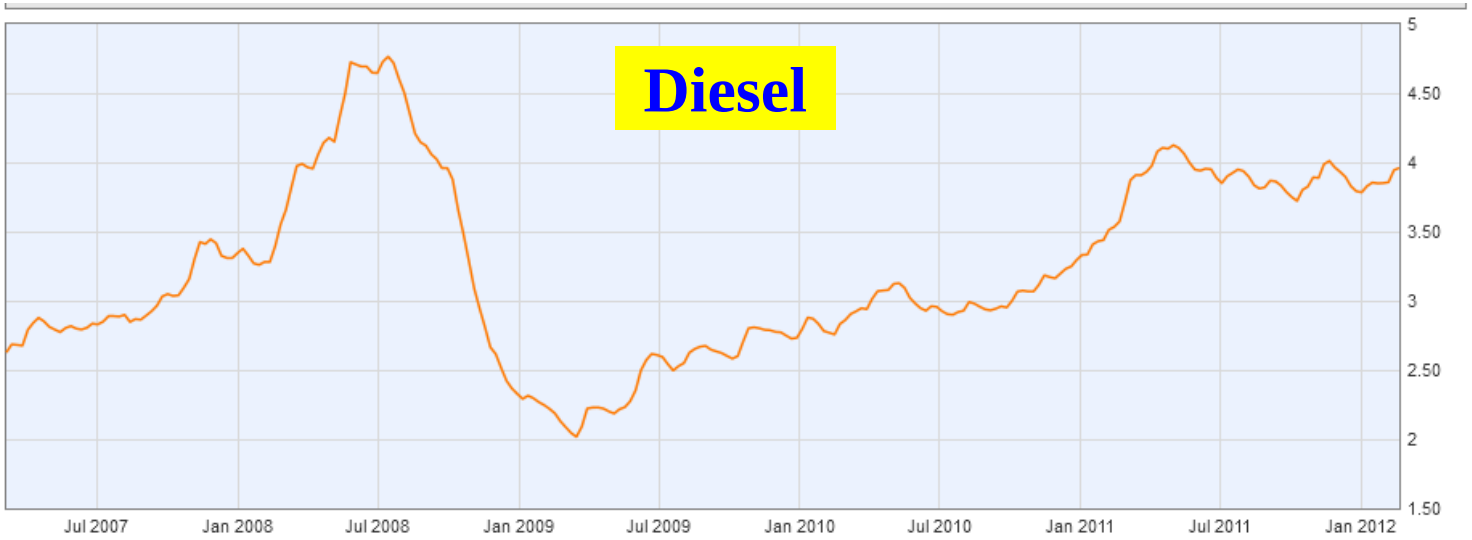
$108.04 ▲0.97 0.91%

13:36 PM EST - 2012.03.01

1m 1q 1y 5y

Less demand for fuel oil
Crude oil: heavier and more diverse
Carbon footprint
Water footprint



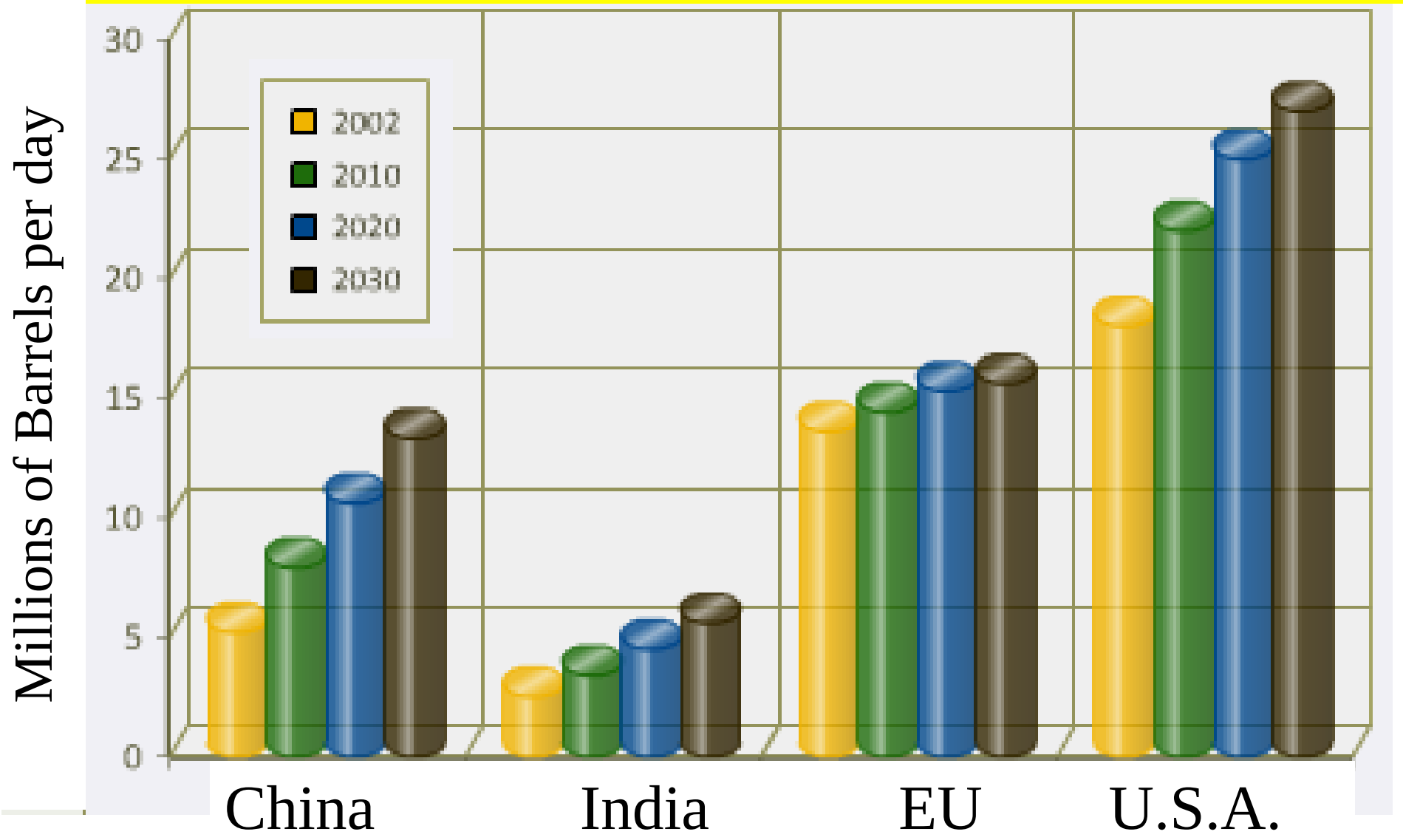


http://www.gasbuddy.com/gb_retail_price_chart.aspx?time=24/

http://ycharts.com/indicators/us_diesel_price

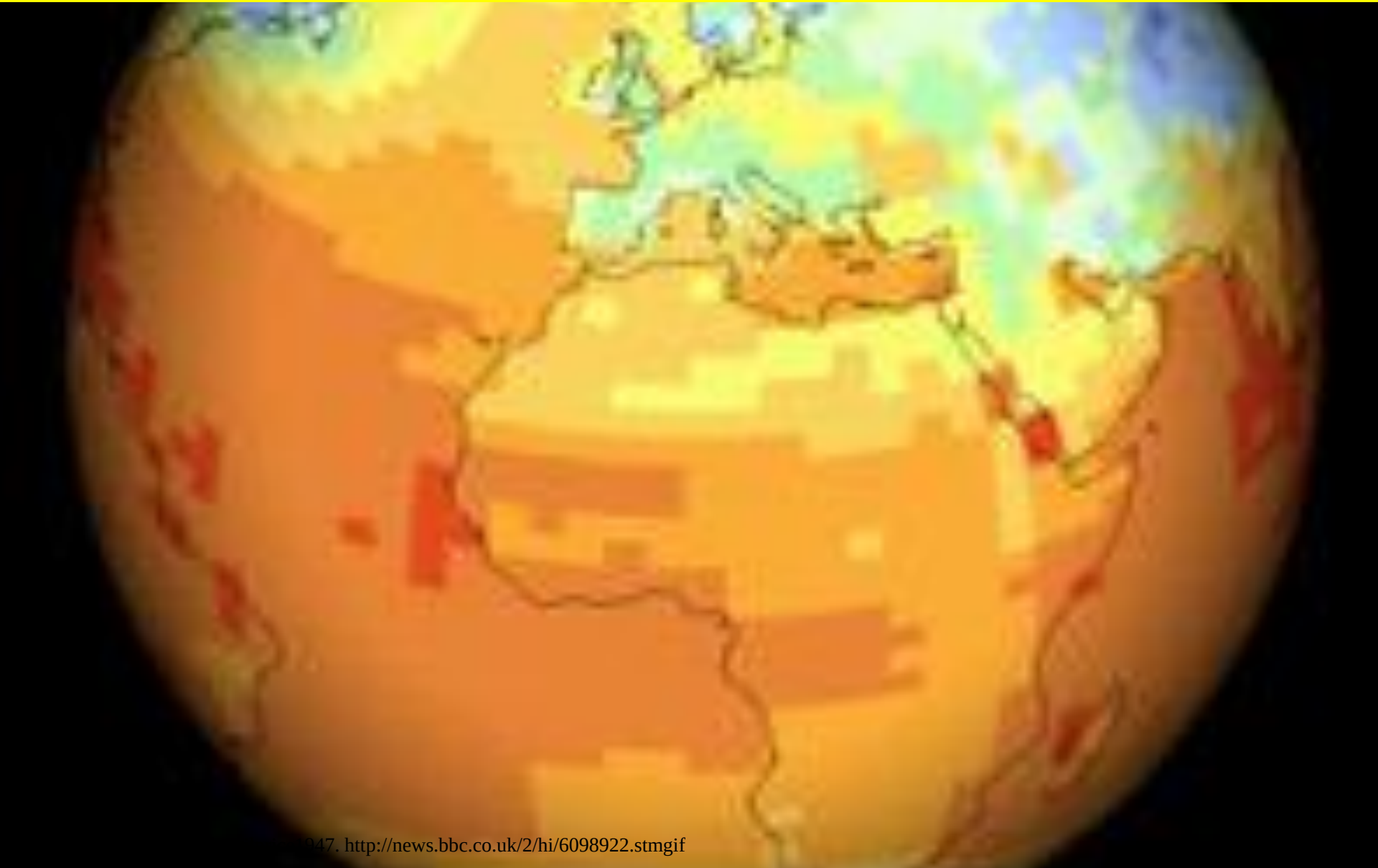
US Regular Gasoline and Diesel Fuel Prices Mar 1, 2012

Global Crude Oil Demands Forecast to 2030



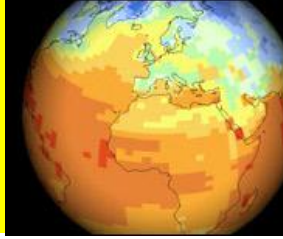
http://www.emerging-markets.com/algae/GlobalCrudeOilDemandto2030.html

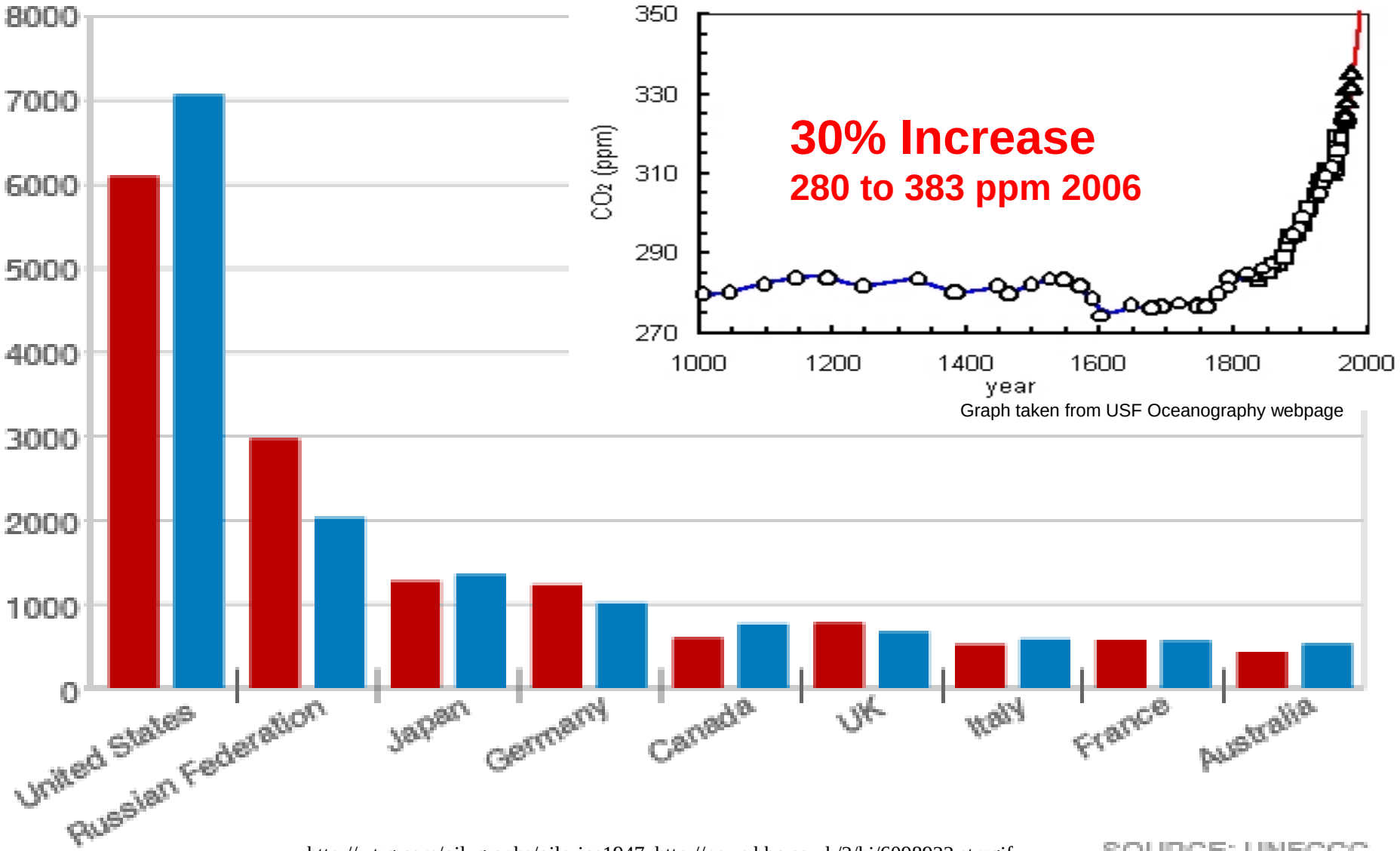
Greenhouse Gas Emission



947. http://news.bbc.co.uk/2/hi/6098922.stmgif

Total Greenhouse Gas Emission (1990 & 2004), Millions tonnes CO2 equivalent (MTCE)





Graph taken from USF Oceanography webpage

http://wtrg.com/oil_graphs/oilprice1947. http://news.bbc.co.uk/2/hi/6098922.stmgif

SOURCE: UNFCCC

Low Carbon Fuel Standards (LCFS)

Purpose: to decrease CO2 emissions of fuel-powered vehicles in order to reduce the carbon footprint of transportation.
The first LCFS mandate in the world was enacted by California in 2007, but taking effect Jan 2011.
Several bills have been proposed in the US for similar low-carbon fuel regulation at a national level but with less stringent standards than California. As of early 2010 none has been approved.

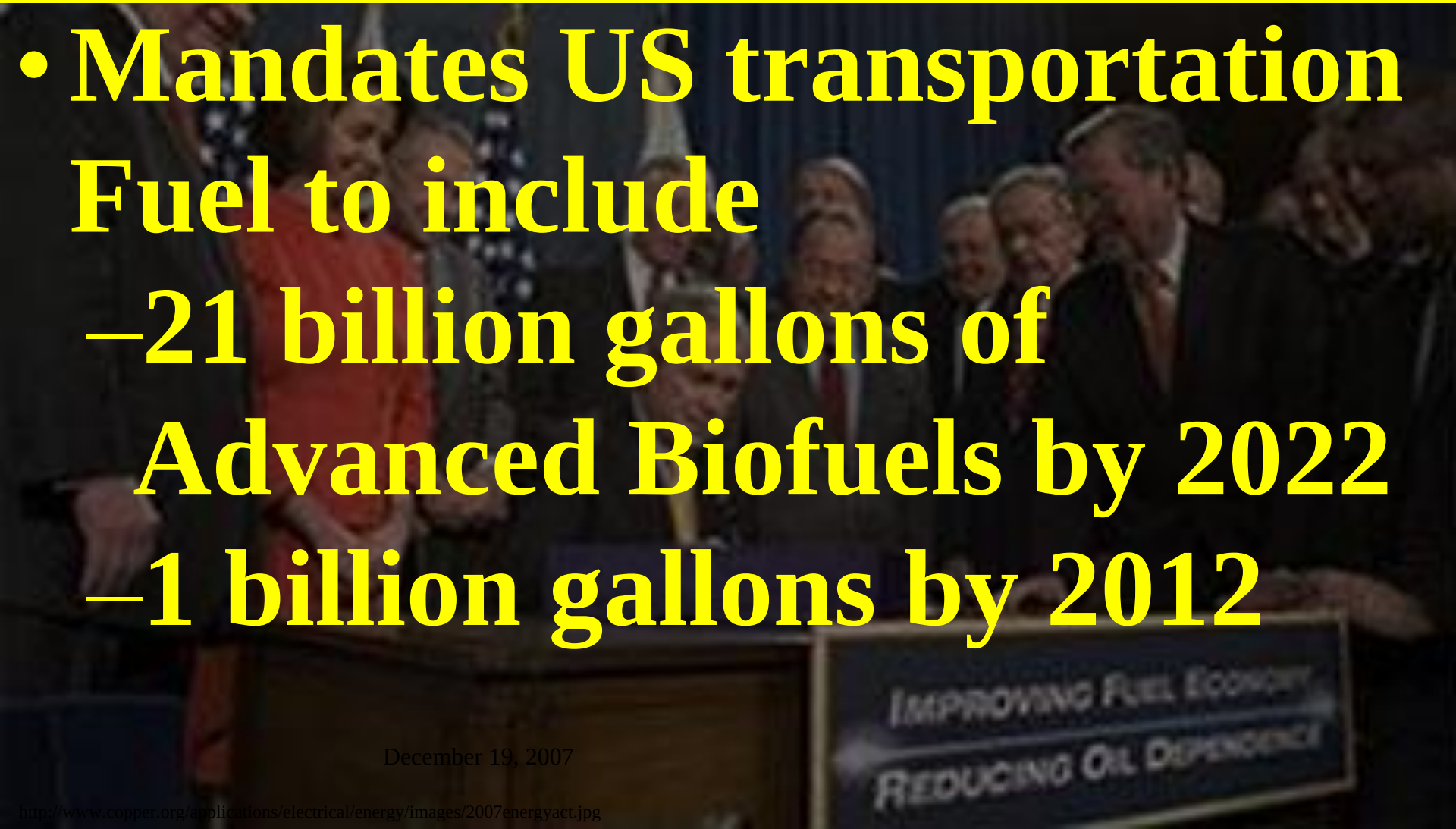
Energy Independence and Security Act of 2007

December 19, 2007

http://www.copper.org/applications/electrical/energy/images/2007energyact.jpg

Energy Independence and Security Act of 2007

- Mandates US transportation Fuel to include
  - –21 billion gallons of Advanced Biofuels by 2022
  - –1 billion gallons by 2012



December 19, 2007

http://www.copper.org/applications/electrical/energy/images/2007energyact.jpg

Renewable Fuel Standard

Lisa Jackson, US EPA, February 3, 2010

CO_2 Emission from Oil Barrel

1 bbl of oil (42 gallons) Produces 310 kg CO_2 (after combustion)

CO2 Emission

Low Carbon or Carbon-Neutral Sustainable Energy Form

Alternative Biofuel Progress

First Generation

Food Sources
Freshwater
Arable Land
Time to Grow

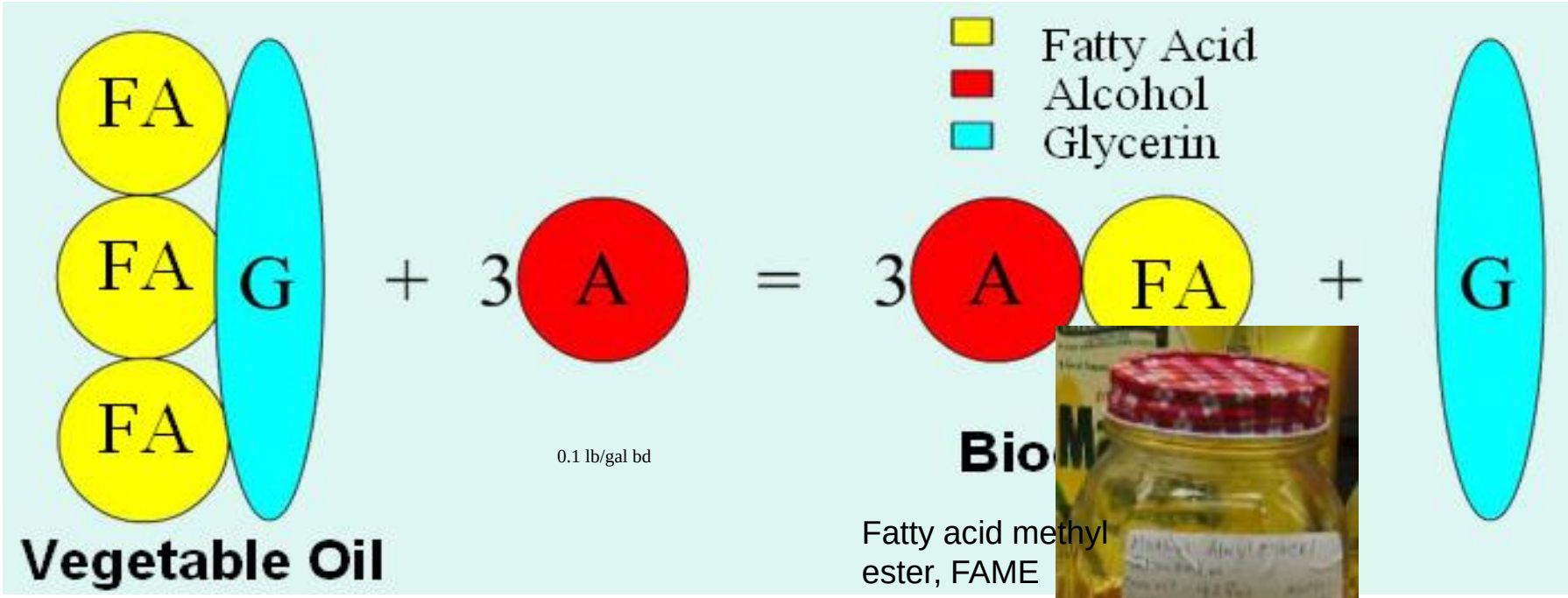
Second Generation

Freshwater
Arable Land
Time to Grow

http://upload.wikimedia.org/wikipedia/commons/thumb/5/5c/Soybeanbus.jpg/220px-Soybeanbus.jpg

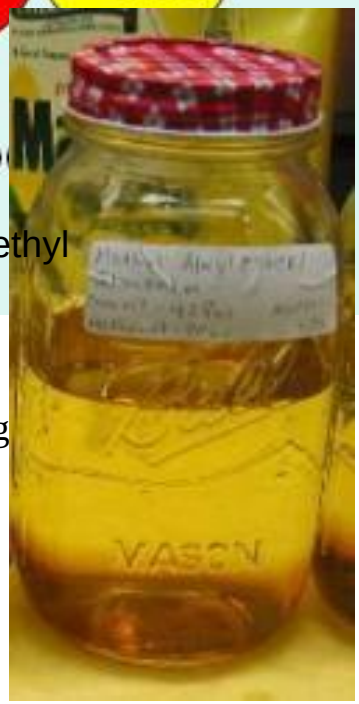
What is Biodiesel?

- **Transesterification Process.**



- 100 lb 11.3 lb (1 lb NaOH) 97 lb =13.3 g 11 lb

- **Clean Burning Alternative fuel for diesel engines**
- **Produced from Domestic Renewable Resources: any fat or oil, like vegetable oil, used greases, animal fat.**

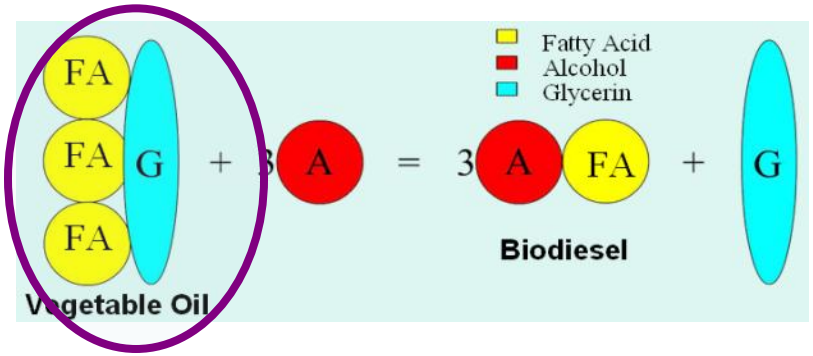
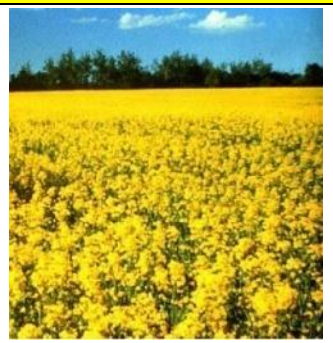


1st step, Diglucerid 2nd step, mono, then 3rd step FAME and glycerol

Biggest Biodiesel Challenge

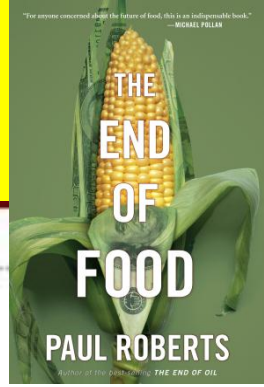
- **Producing enough feedstock oil to replace a large portion of petroleum diesel**

Oil & Biodiesel yield of Soybeans & Canola

	 **Soybeans**	 **Canola**
Gallons biodiesel/acre	50	92
Acres/million gallons BD	~24,000	~14,000

http://www.pioneer.com/usa/agronomy/soybeans/biodiesel.htm

Tortilla Riots



Last Updated: Thursday, 1 February 2007, 01:56 GMT

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Mexicans stage tortilla protest

A peasant protests in Mexico City at the rising price of corn. Photograph: Luis Acosta/AFP

Tens of thousands of people have marched through Mexico City in a protest against the rising price of tortillas.

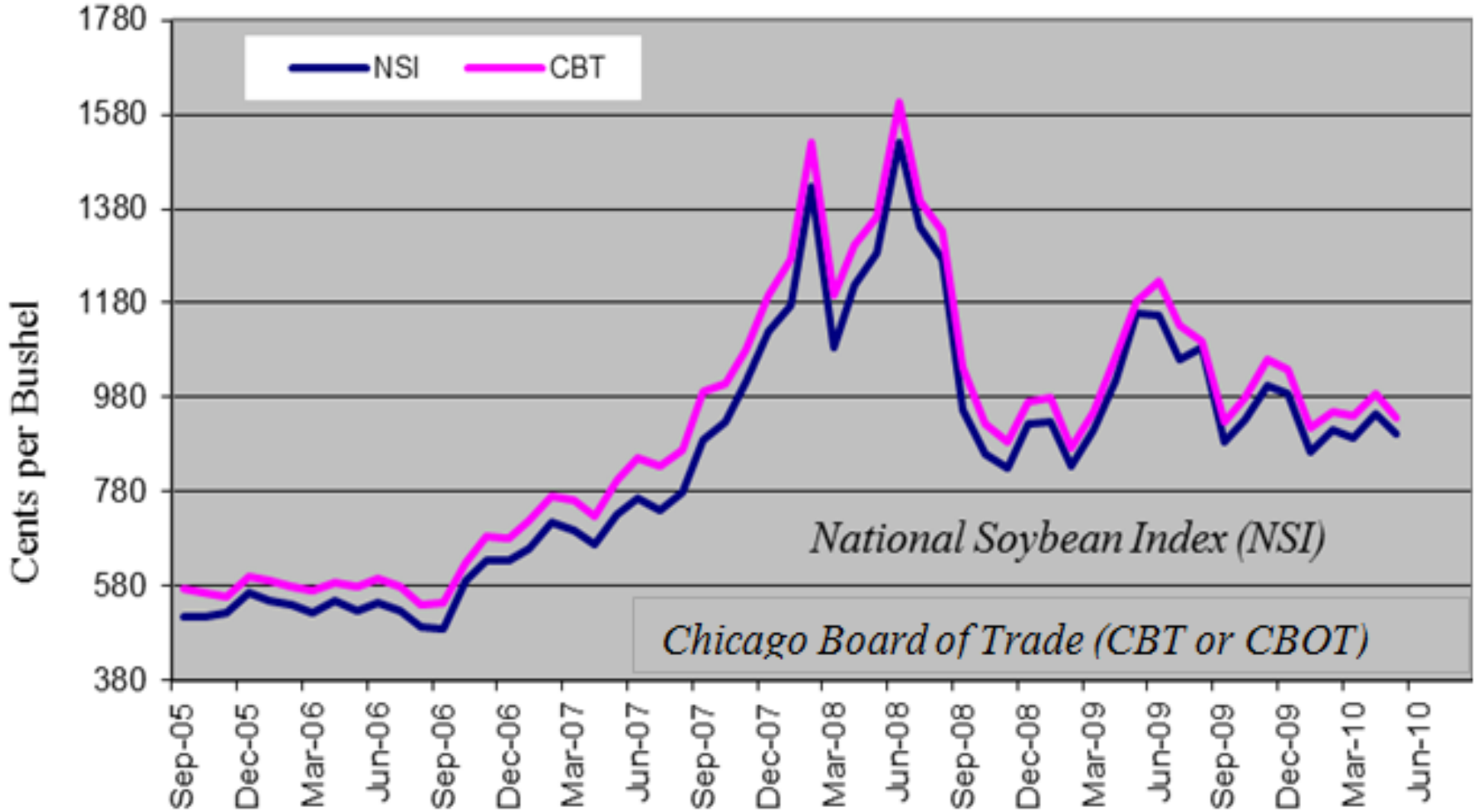
The price of the flat corn bread, the main source of calories for many poor Mexicans, recently rose by over 400%.

Mexicans are angry at the rise in price of their staple food

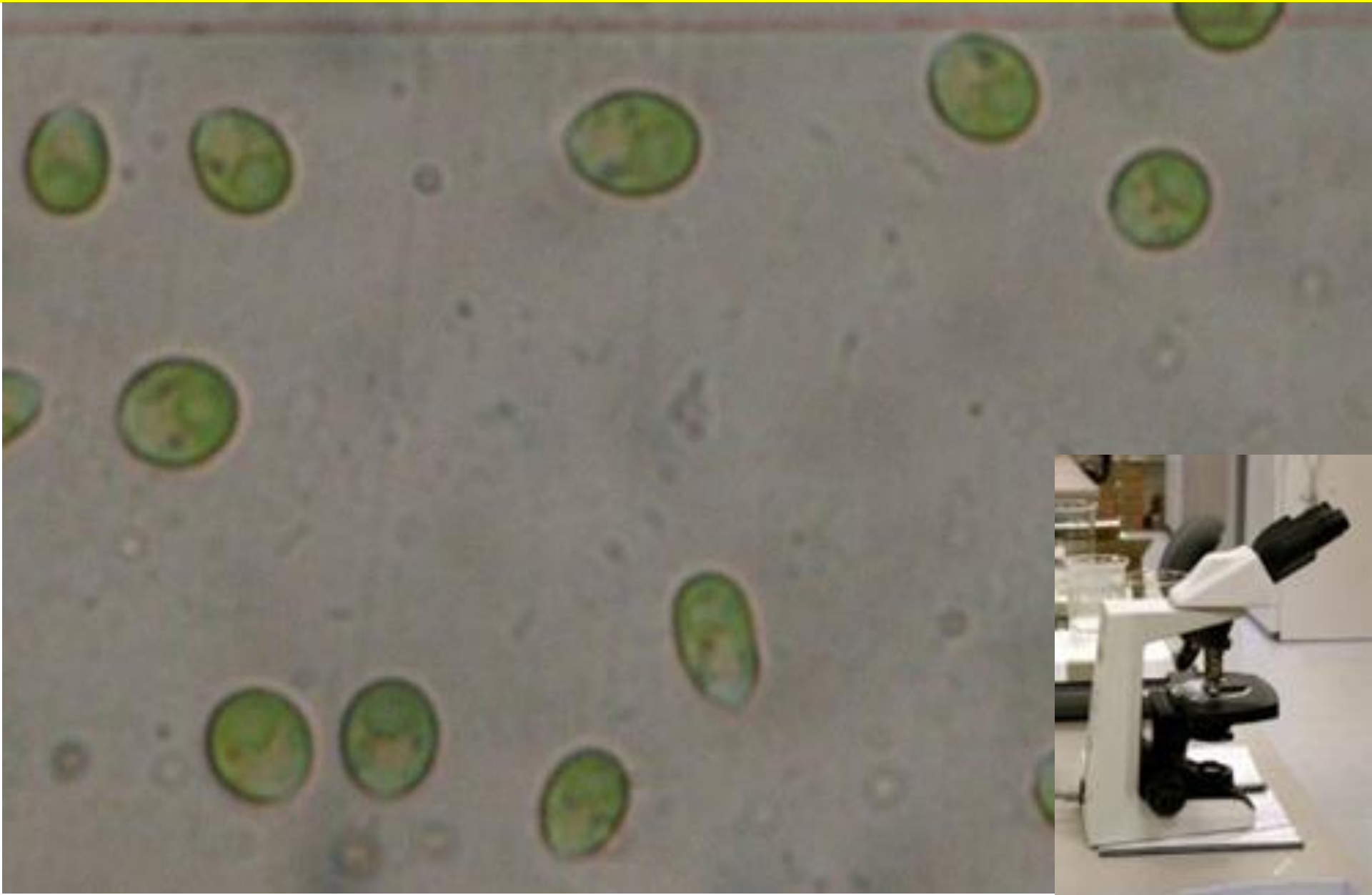
President Felipe Calderon has said the government will clamp down on hoarding and speculation to ease the problem.

But some blame the rise on demand for corn to make environmentally-friendly biofuels in the United States

Soybean prices overtime, c/bushel (NSI 2009)



The New Frontier

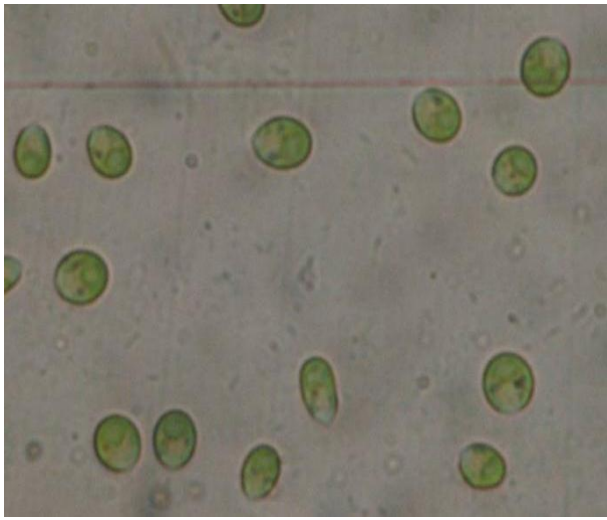


Alternative Biofuel Progress

First Generation

Second Generation

Third Generation



http://upload.wikimedia.org/wikipedia/commons/thumb/5/5c/Soybeanbus.jpg/220px-Soybeanbus.jpg

What are Algae?

- Plant-like organism
- Simple: no leaves, no roots
- Live in water
- Fast Growth

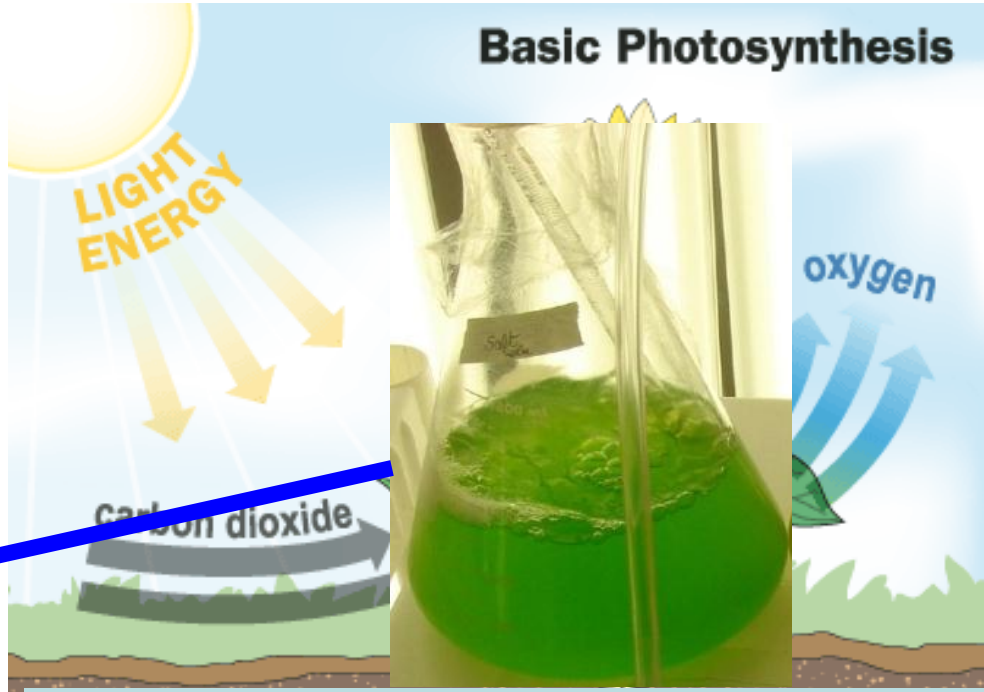
http://tbn0.google.com/images?q=tbn:rclb7UEFr98Z_M:http://www.microimaging.ca/bursaria.jpg

Algae to Biodiesel

- Simple plant-like organism
  - Photosynthesis

$6\ CO_2 + 6\ H_2O + 8\ photons \rightarrow C_6H_{12}O_6 + 6\ O_2$

$C_6H_{12}O_6 \rightarrow$ Triacylglycerides (TGA) (lipid/oil)



10-40 wt % Lipids

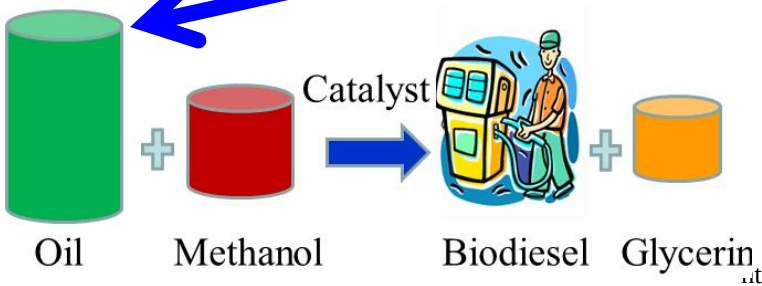
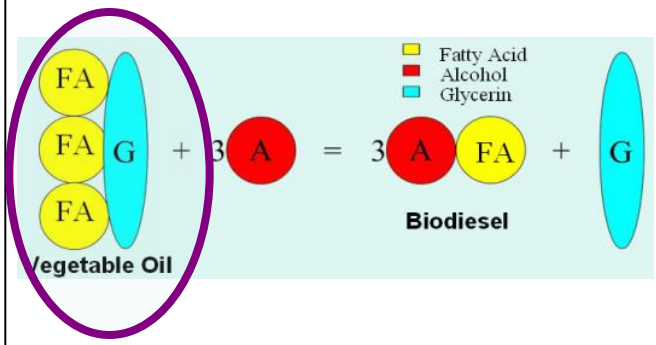


Photo-Bioreactor

http://grapevine.net.au/~grunwald/une/KLAs/science/irrigation-photosynthesis.gif

http://tbn0.google.com/images?q=tbn:rclb7UEFr98Z_M:http://www.microimaging.ca/bursaria.jpg

Oil & Biodiesel yield of Soybeans, Canola & Algae

	 **Soybean**	 **Canola**	 **Algae**
Gallons biodiesel/acre	50	90	1000-10000
Acres/million gallons BD	~24,000	~14,000	~130

http://www.pioneer.com/usa/agronomy/soybeans/biodiesel.htm, 60 billion gal biodiesel = 8 million acres

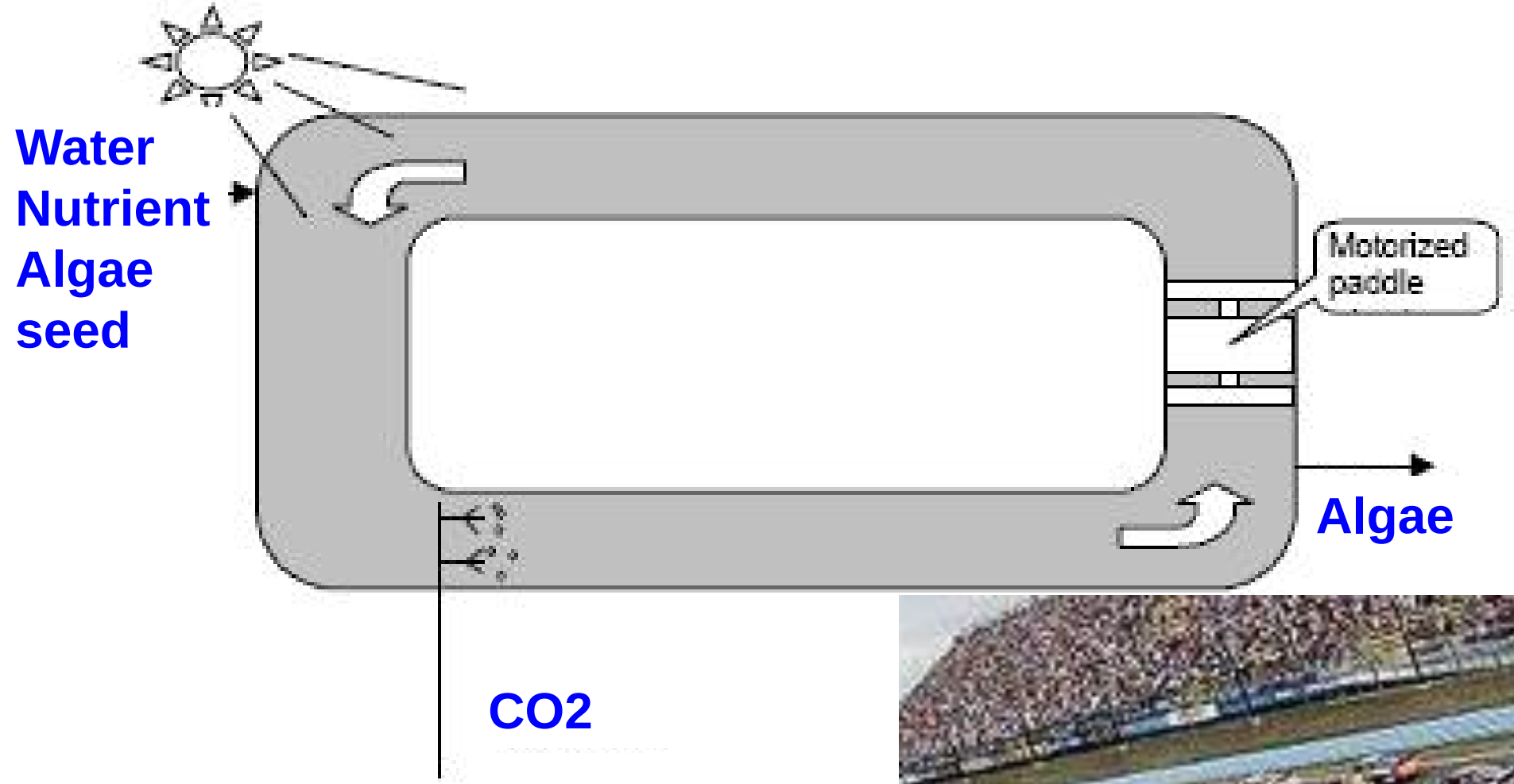
The Algae Promise?

http://www.cgcfields.com/CarolinaGreenAssets/Projects/ProjectsPhoto11.jpg

claims that algae can produce more oil in an area the size of a two car garage than a football field of soybeans, because almost the entire algal organism can use sunlight to produce lipids, or oil.

Large Scale Algae Growth: Algaculture (Farming Algae)

Large Scale Algae Growth: Raceway Ponds



http://students.chem.tue.nl/ifp23/interim_report/algae2.jpg

Large Scale Algae Growth: Raceway Ponds

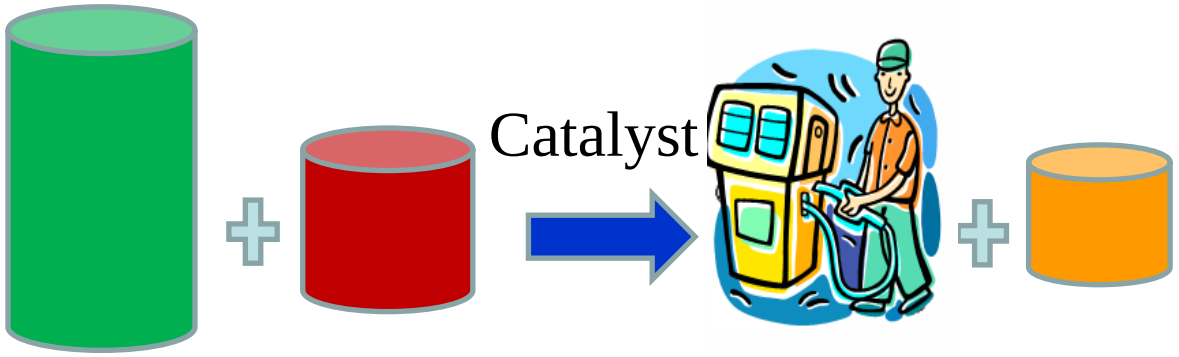
Algae Growth: 80 L Photobioreactor

UNH Biodiesel Lab

Microalgae Oil to Biodiesel

Harvest and Oil Extraction

Transesterification



Oil Methanol Biodiesel Glycerin

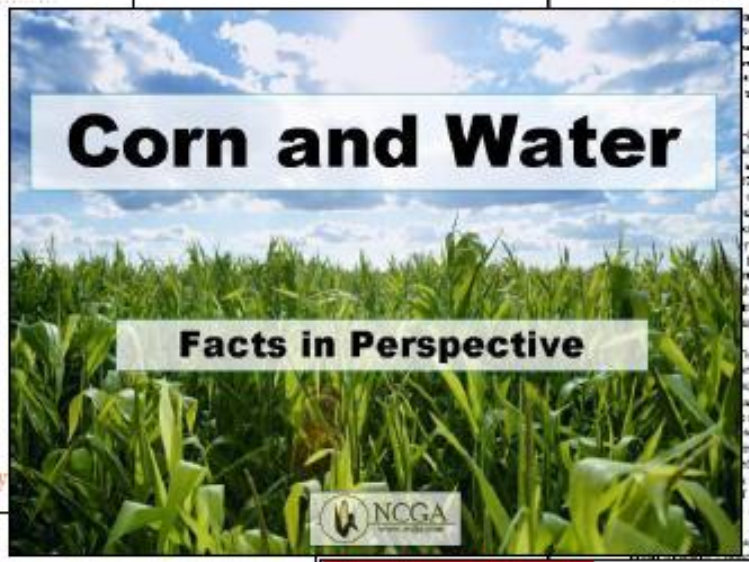
http://t0.gstatic.com/images?q=tbn:P1oM7SaokdyFwM:http://www.cityofmenasha-wi.gov/content/departments/public_works/images/Algae-SM.jpg

http://www.wired.com/images_blogs/autopia/images/2008/05/29/hirescrude_2.jpg

Biofuel Sustainability: Water

Water Use
by Ethanol Plants
Potential Challenges

Institute for Agriculture and Trade Policy



THE NATIONAL ACADEMIES
REPORT IN BRIEF
October 2007

Water Implications of Biofuels Production in the United States

The New York Times
nytimes.com

October 11, 2007

Panel Sees Problems in Ethanol Production

By CORNELIA DEAN

Greater cultivation of crops to produce ethanol could harm water quality and leave some regions of the country with water shortages, a panel of experts is reporting. And corn, the most widely grown fuel crop in the United States, might cause more damage per unit of energy than other plants, especially switchgrass and native grasses, the panel said.

BusinessWeek

THE ASSOCIATED PRESS October 11, 2007, 11:59AM ET

India, China biofuels may sap water

By MICHAEL CASEY

BANGKOK, THAILAND

China's and India's plans to produce more biofuels could cause shortages of water, which is needed for crops to feed their growing populations, according to a water study released Thursday.

The International Water Management Institute or IWMI study said both countries are counting on maize and sugarcane, which need large amounts of water, for much of their biofuels.

Sandia National Laboratories

Estimate

Soybean

15600 gal
water/gal BD

300 - 2000 gal
water/gal BD

Biofuel

Drink-or-Drive

http://0.tqn.com/d/alternativefuels/1/0/i/O/-/-/09_Mullen_GTEV.jpg

http://www.shapelife.co.za/blog/wp-content/uploads/2009/08/j0422274.jpg

Reducing the Water Footprint of Algae Growth

Non-Fresh (Impaired) Water use in Algae

- Municipal Wastewater
- Wastewater from Agriculture
- Sea water

Microalgae Applications

Algae Oil Hybrid Car

http://www.theglobalenergy.com/updates/bio-diesel-train-india-launches-eco-friendly-train/

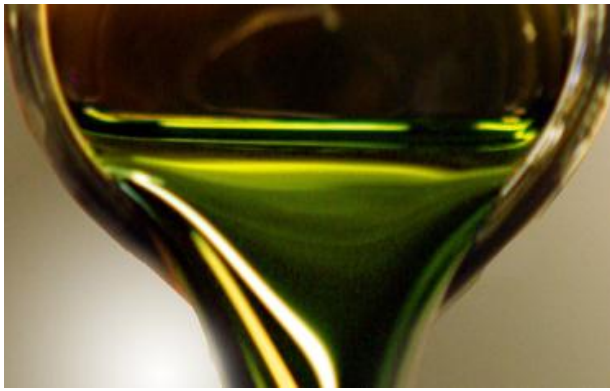
http://www.theglobalenergy.com/updates/bio-diesel-train-india-launches-eco-friendly-train/

Algae Biodiesel Train

Air New Zealand tested flying Boeing 747 with Biodiesel, Dec 31, 2008

Microalgae Jet Fuel Production

Oil Extraction



Refining

U.S. military plans for large scale production of aviation biofuel, 50 million gal./yr, expected 2013

Neutraceuticals: Omega 3 oils

- Market demand for omega 3 is increasing at 26% per year world wide
- Marine fisheries are being depleted.
- Vegerterian source, (600 million in India)

Microalgae Fish Farming

Microalgae Cosmetics: Moisturizers

http://www.seaweedireland.com/mudmask.jpg

Microalgae Pharmaceuticals for Aquarium

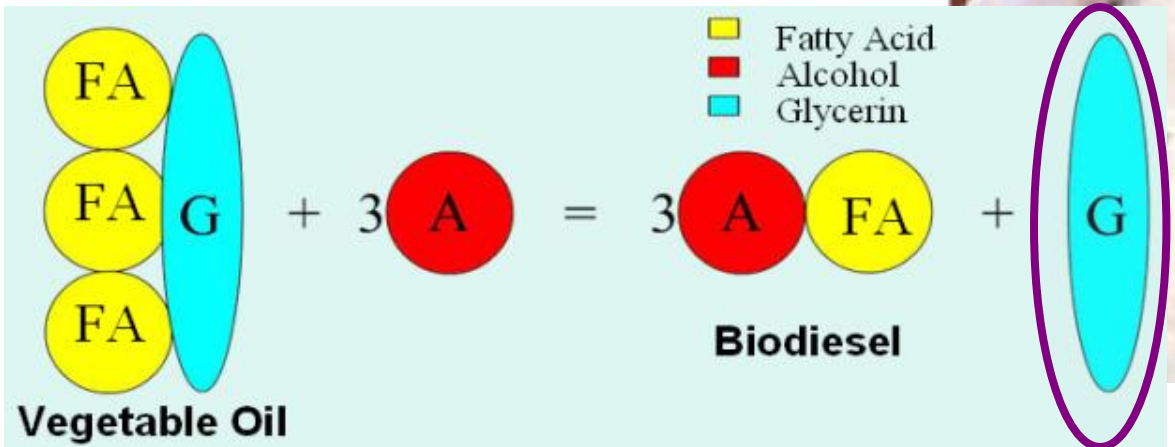
http://www.halfoffponds.com/images/products/detail/AlgaeFixGroupShot.3.jpg

Microalgae Applications

- Biodiesel
- Jet Fuel
- Biogasoline
- Bioplastics
- Fish Farming
- Neutraceuticals
- Pharmaceuticals
- Cosmetics
- Organic Fertilizers
- Bioplastics

Glycerin Byproduct Research

- **Cost-effective use of Glycerin Byproduct**



Algae Oil Commercial Developments

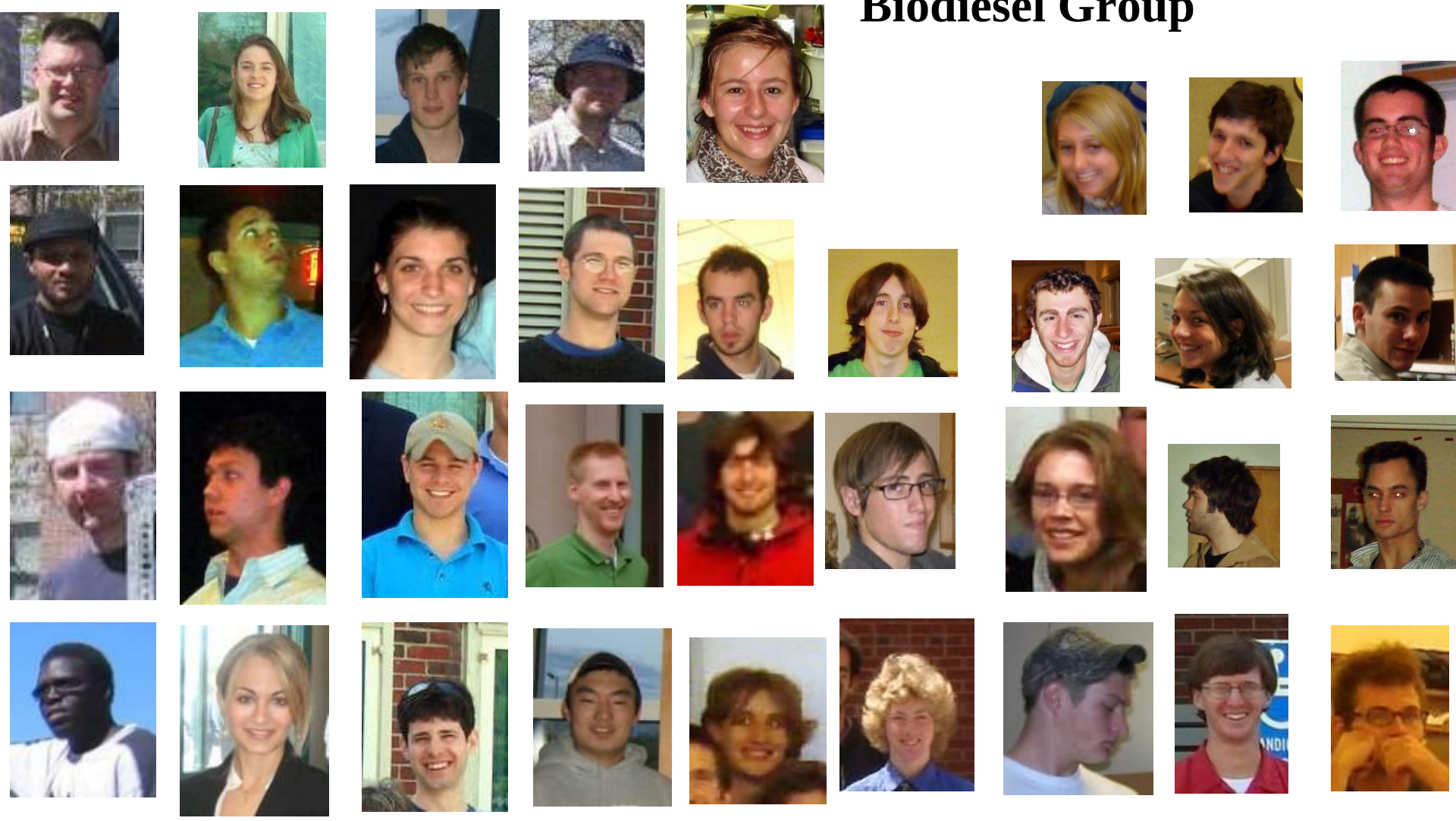
- Exxon and Bill Gates are investing in algae
- Algae farms are starting to scale-up

Recap

- Motivation
- Biodiesel & Challenges
- Microalgae
- Water Issues
- Applications
- Commercial Developments

Acknowledgment

- **Members of the UNH Biodiesel Group**



Thank you for your time.